

# Mercury, Selenium and Selenium: Mercury ratios in Fish and Risk Management



Joanna Burger and Michael Gochfeld

Rutgers University  
NIEHS Center and EOSHI

# Objectives: Variability -> unpredictability



- Brief background on mercury and selenium
- Mean levels of mercury and selenium among species
- Mean levels of mercury and selenium within species
- Variations in level with fish size and location
- Selenium:mercury molar ratios for species or locations
- Selenium:mercury molar ratios in individuals
- Selenium:mercury molar ratios in other tissues

Bluefin Tuna

# Mercury and Selenium

- Selenium is both a toxic and essential element
- Mercury has high affinity for sulfur AND selenium
- Mercury can disrupt selenoenzymes including those that defend against oxidative stress (thioredoxin reductase)
- Selenium can confer some protection against Hg
- How much protection does selenium in fish confer against MeHg in fish



# A Tale of Two Metals

## ● Mercury


- Many forms
- Toxic in bioavailable forms
- Multiple effects -- form and dose
- Natural and anthropogenic
- Contaminant of foods, particularly piscivorous fish and mammals

## ● Selenium

- Many forms
  - $\text{Se}^{6+}$ ,  $\text{Se}^{4+}$ ,  $\text{Se}^0$ ,  $\text{Se}^-$
- Essential element
- Effects of both deficiency and excess
- Natural and anthropogenic
- Found in water and several foods including fish

# Selenium Deficiency Does Not Look Like Mercury Toxicity Clinically

- Impaired cell-mediated immunity
- Liver damage
- White muscle disease in livestock
- Pancreatic atrophy in chickens
- Alopecia
- Myopathy
- Cardiomyopathy Keshan disease (China)
- Degenerative osteoarthritis-dwarfism (Kashin-Beck disease)
- “Nephrosis”
- Goiter
- Neural tube defects
- Small testes immotile abnormal sperm
- Male infertility in livestock



# Hypothesis : Molar ratio

- It has been suggested that if the Se:Hg ratio  $>1$ , there would be no mercury effects
- However,
  - Choi et al (2008)
    - Se was present in Faroese cord blood: 10 fold molar excess above MeHg. “Overall, no evidence was found that Se was an important protective factor against MeHg neurotoxicity”.
  - Saint-amour et al (2006)
    - Visual evoked potential in Inuit children affected by MeHg; no interaction with measured cord blood Se; average blood Se =5.6  $\mu\text{mole/L}$ ; 20% of population, Se at levels  $>$  safe level for adults.
- The protective ratio in fish is NOT KNOWN



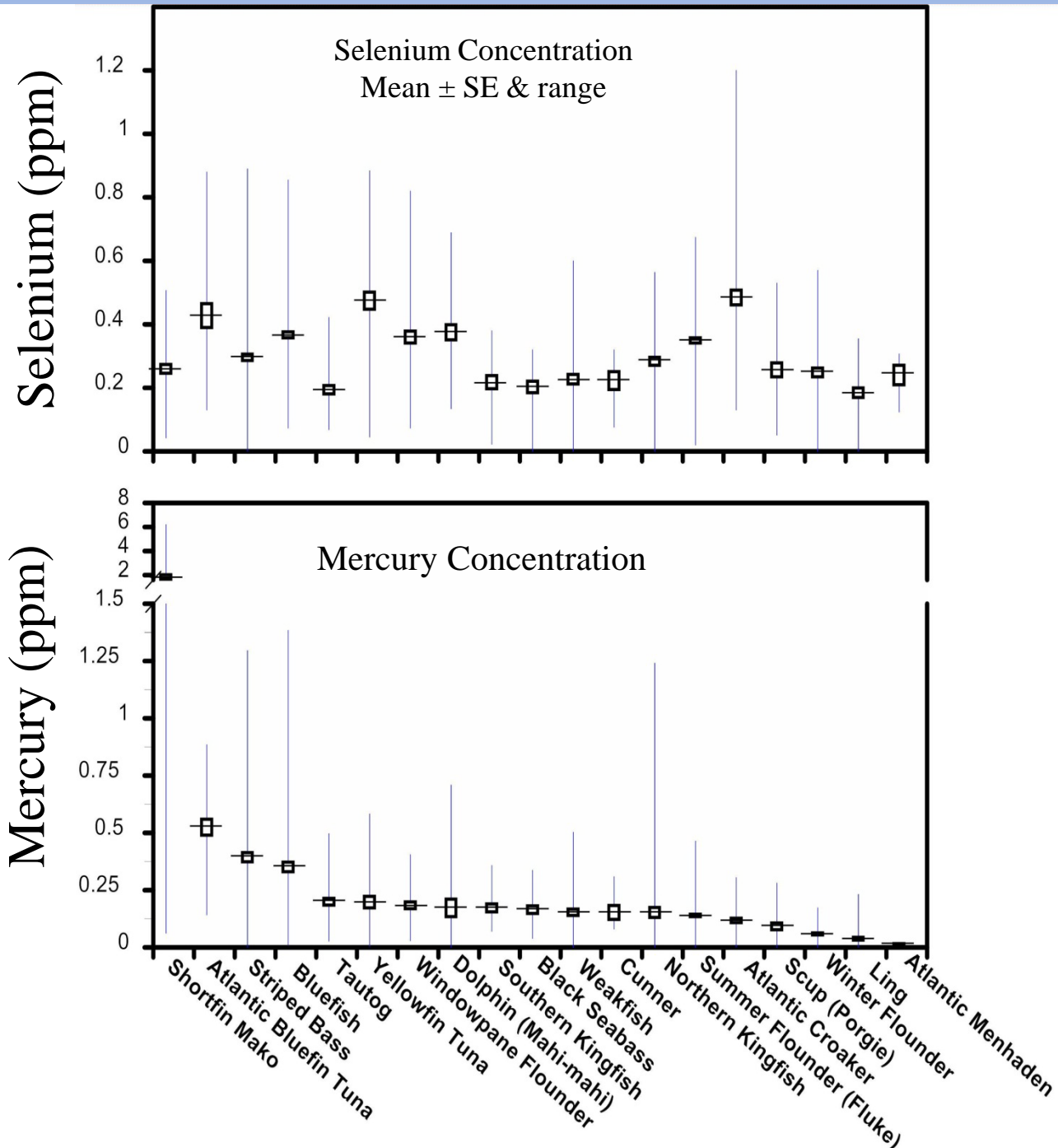
# Modes of action

- Mercury does other things than bind and deplete selenium
  - Disruption of S-S bonds in enzymes
  - Alters temporal sequencing of polysialylated NCAM and sialyltransferase
  - Timing of dose influenced impact during synaptogenesis in cerebellum (Dey et al.)
  - Disrupts microtubules, neuronal migration, processes and synapses
- **Selenium has to do other things than bind mercury**
  - **Binds other cations (copper and cadmium)**

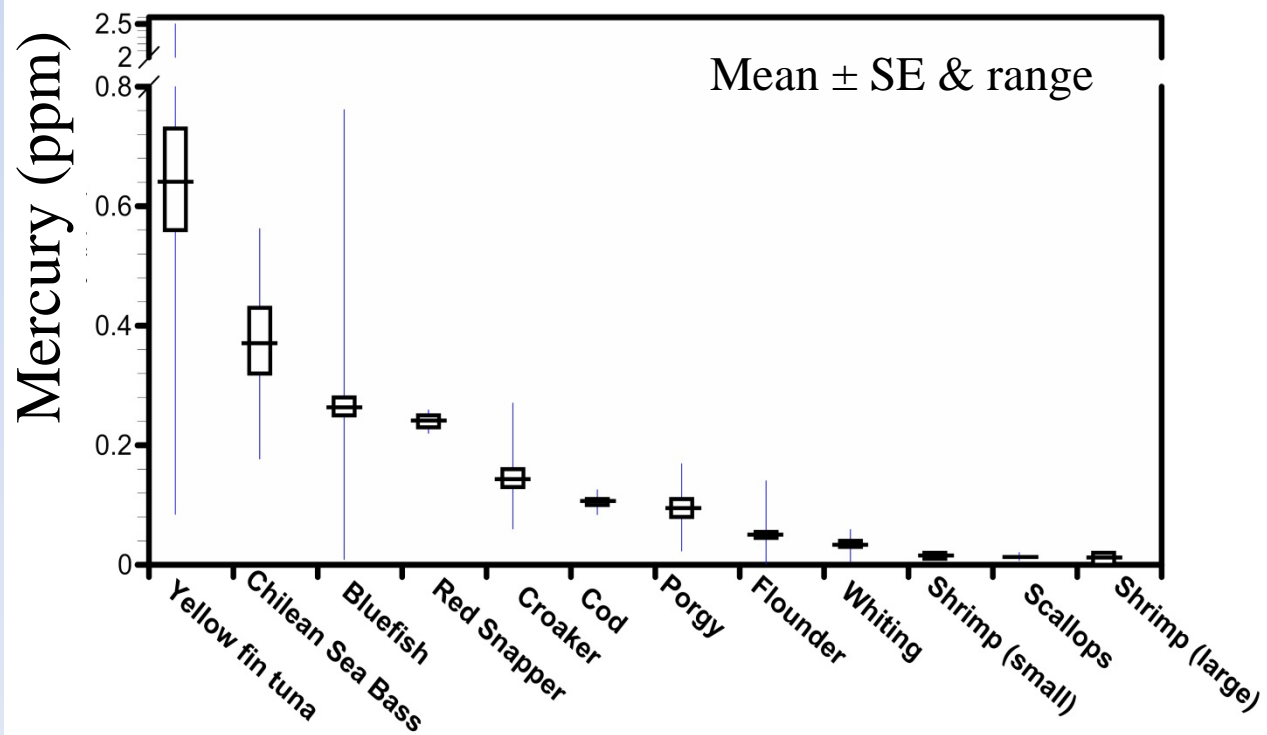
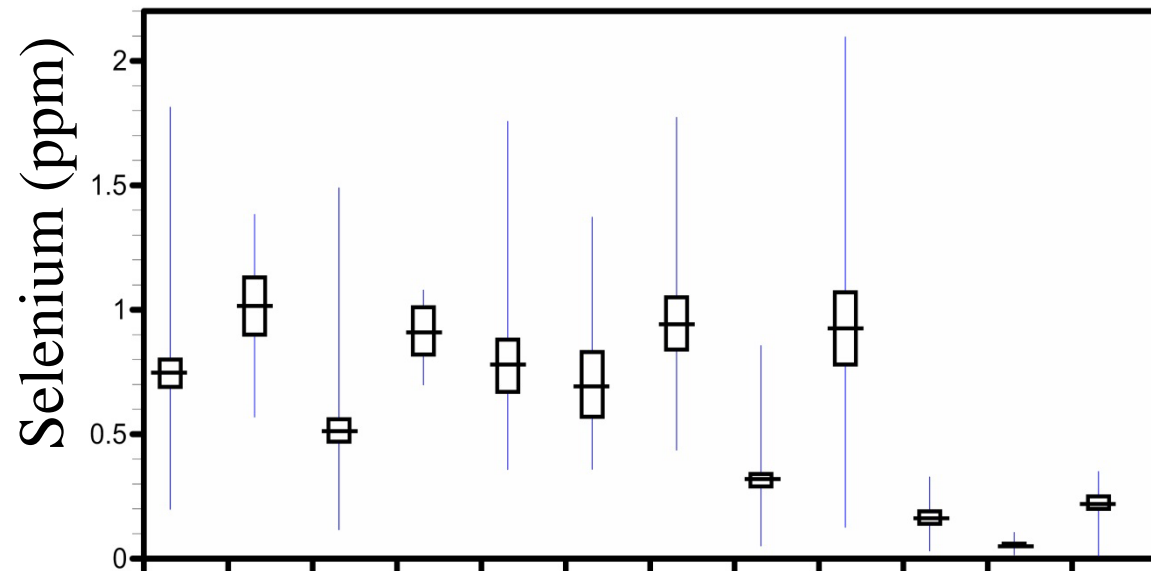
# Current status

- There is a rapidly growing amount of phenomenologic data on Hg-Se interactions.
- Studies are not consistent
- **Some** selenium compounds protect against **some** mercury toxic effects in **some** organisms under **some** test systems.
- Oxidative stress is one mechanism of mercury toxicity (inhibition of GPx and ThR-R)
- Conversely antioxidant defense is a mechanism of Se protection
- How this effects interpretation of the selenium:mercury ratio in fish needs more research.

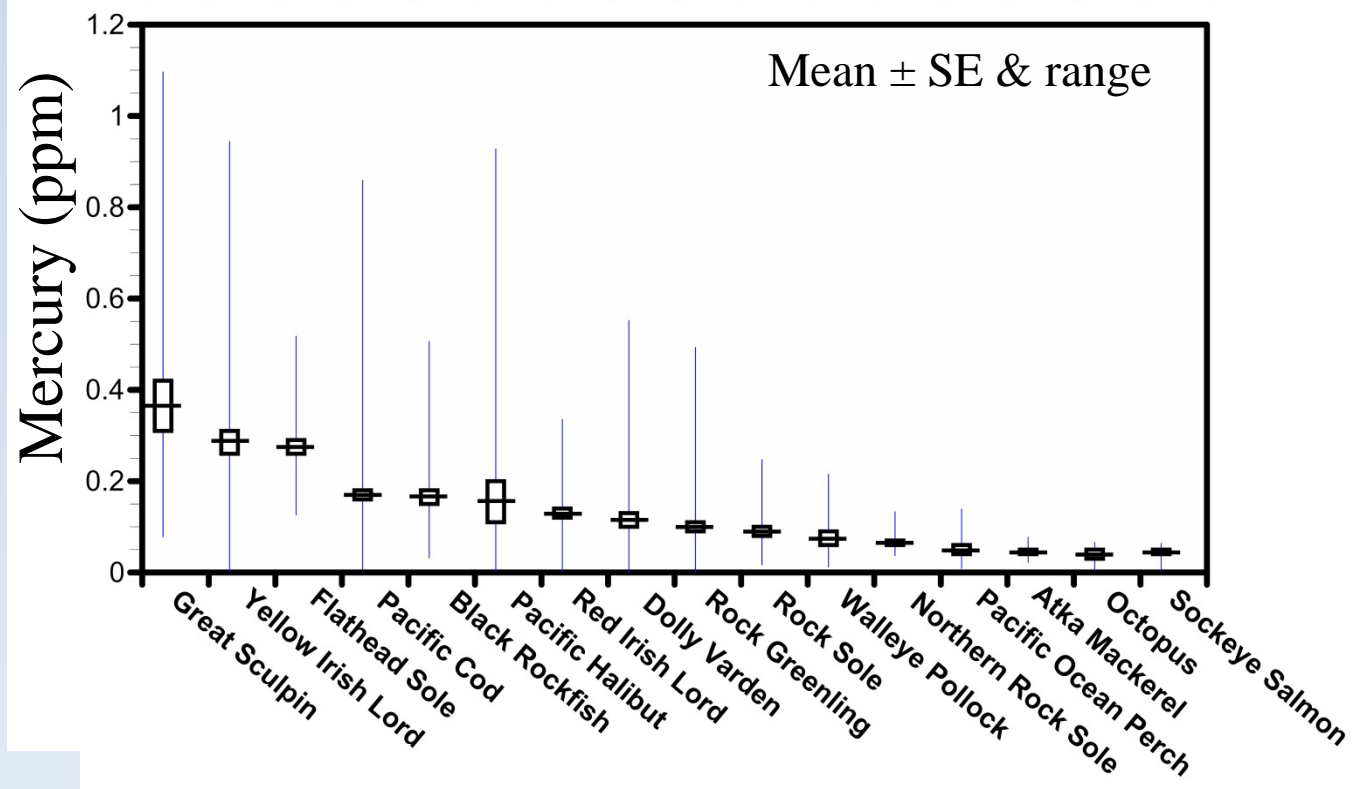
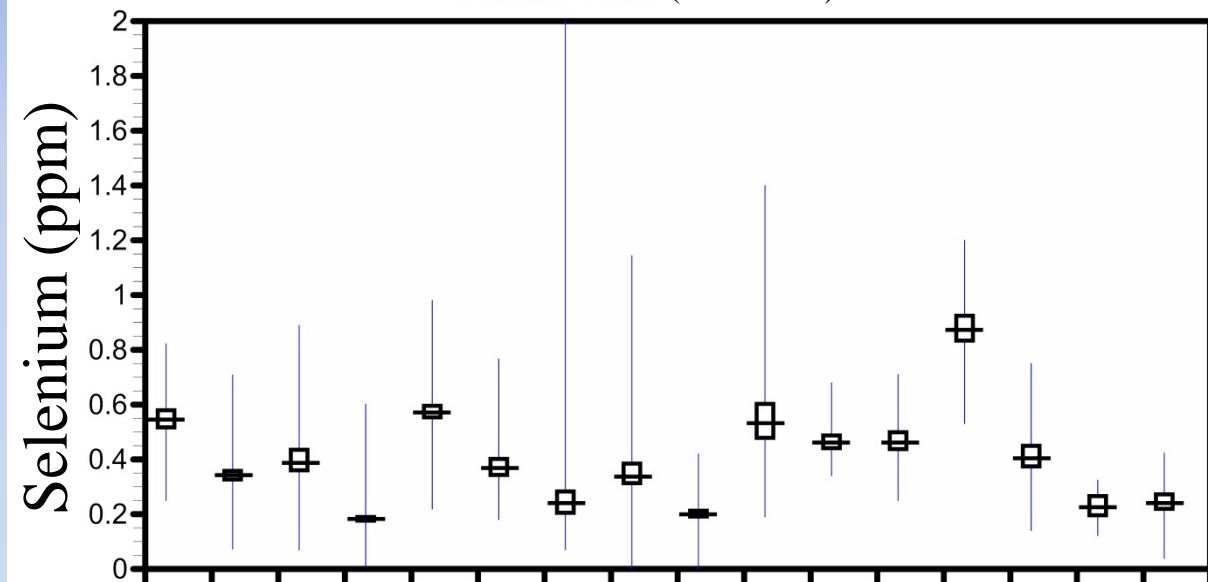




# NJ Commercial Seafood

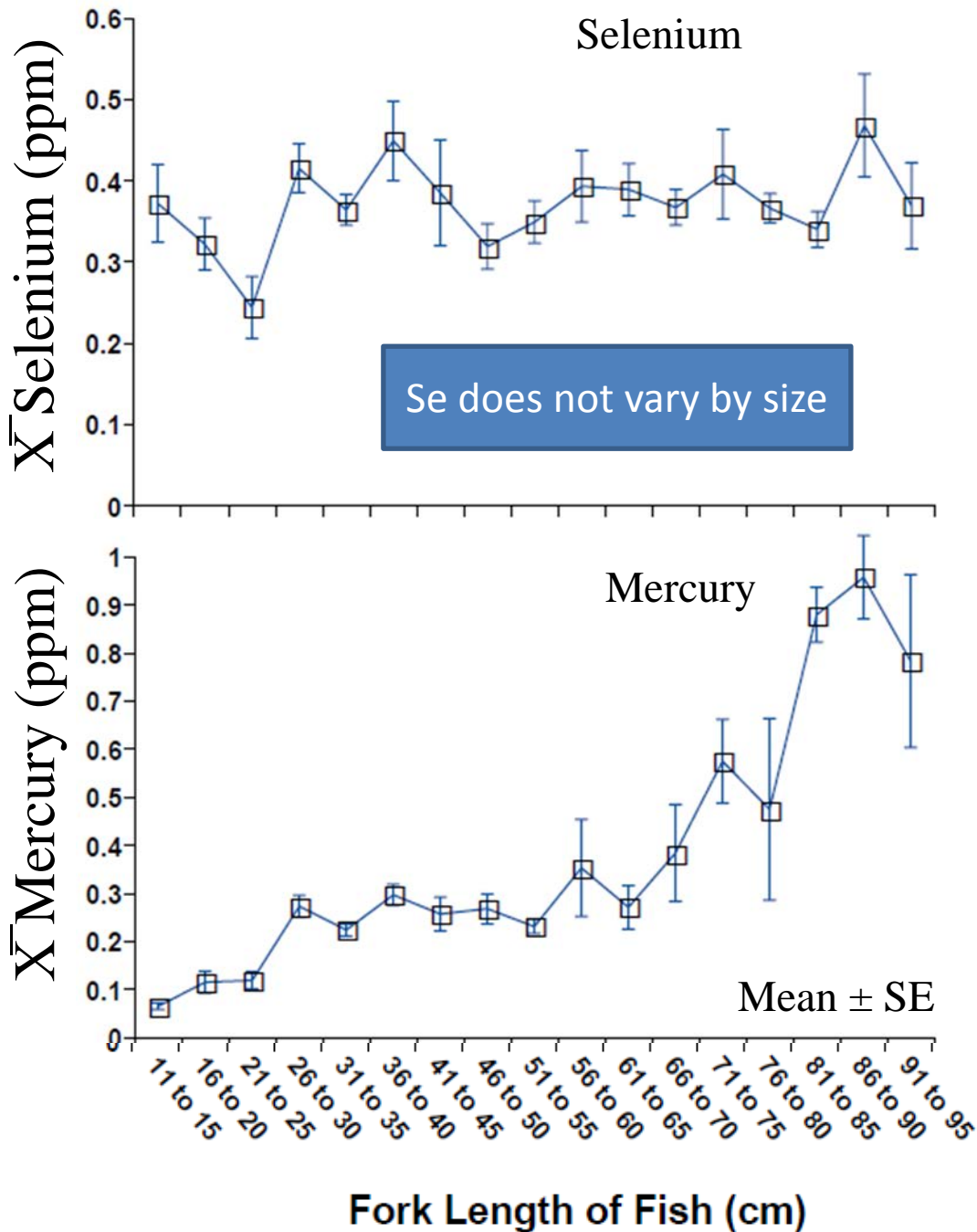


Alaska Fish (Aleutians)

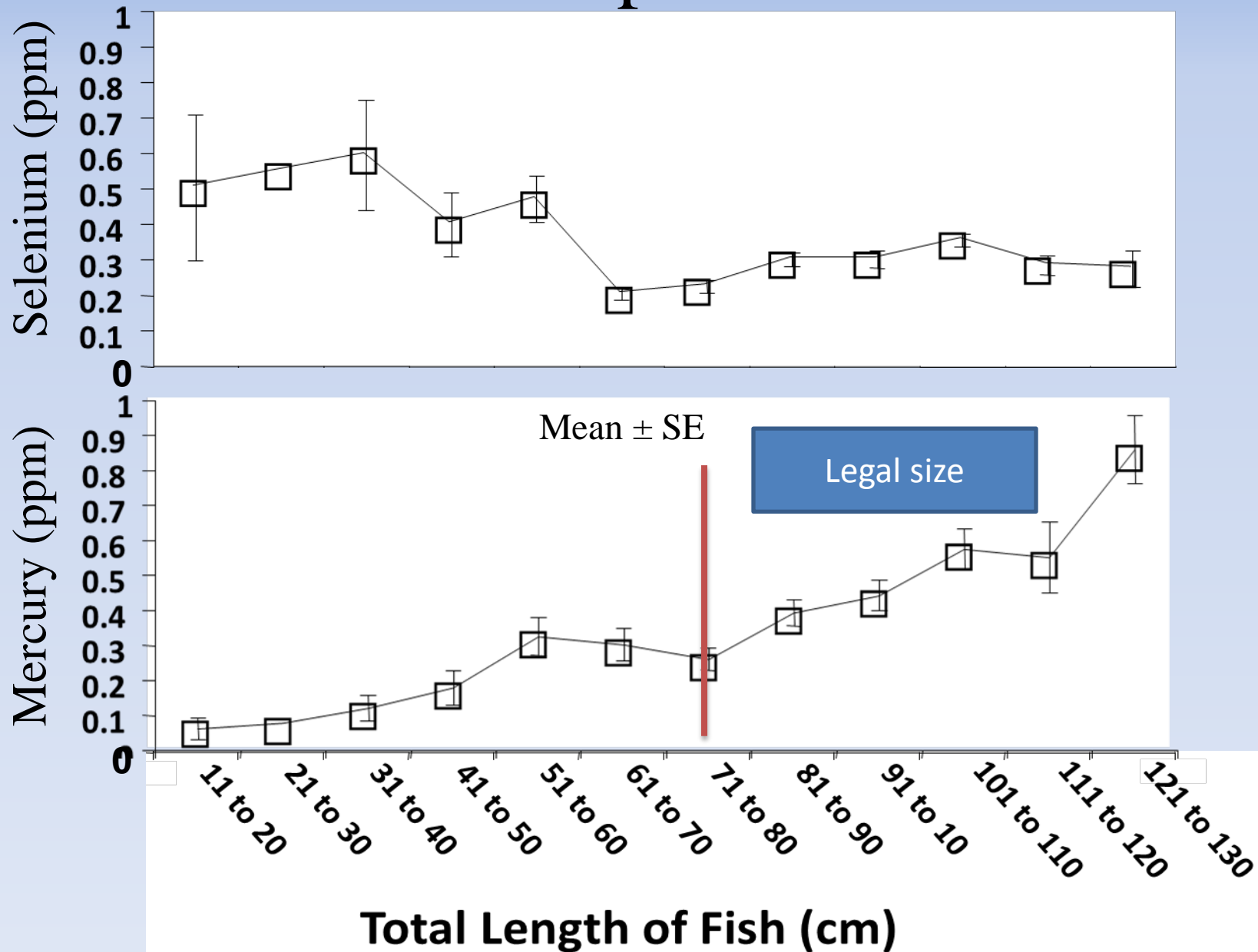


Mean  $\pm$  SE & range

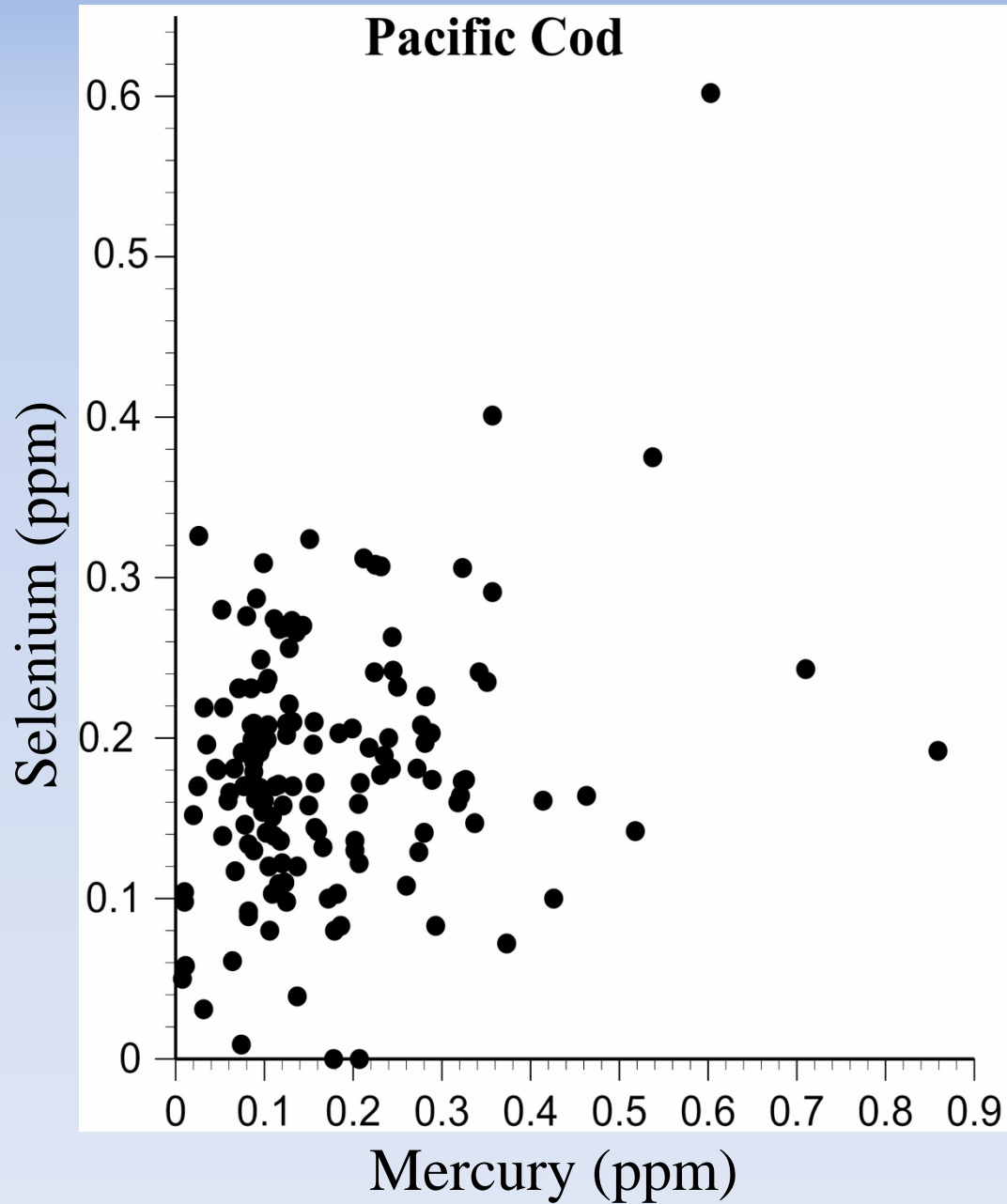
# Bluefish



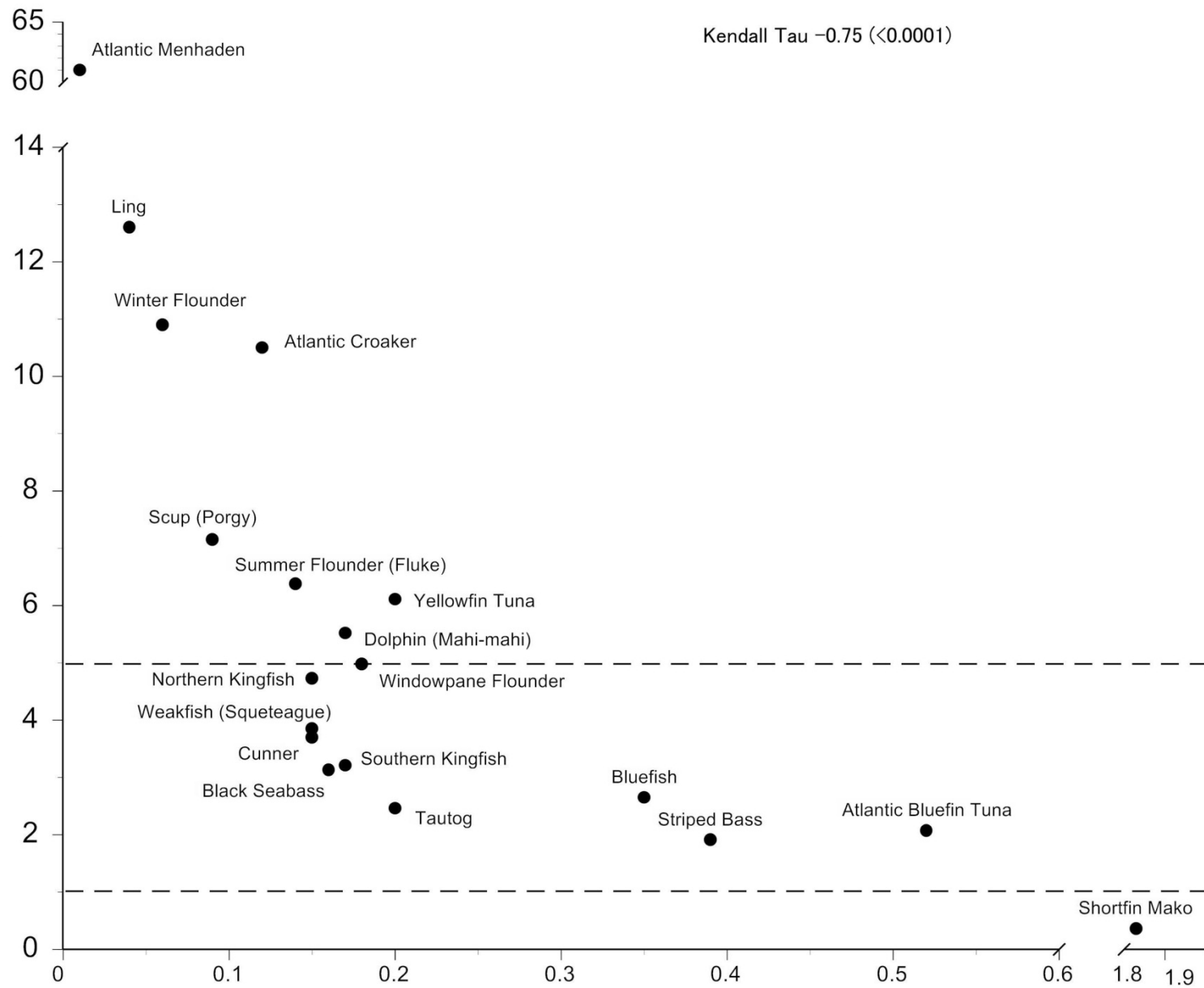
# NJ Striped Bass



## Selenium Mercury Correlations



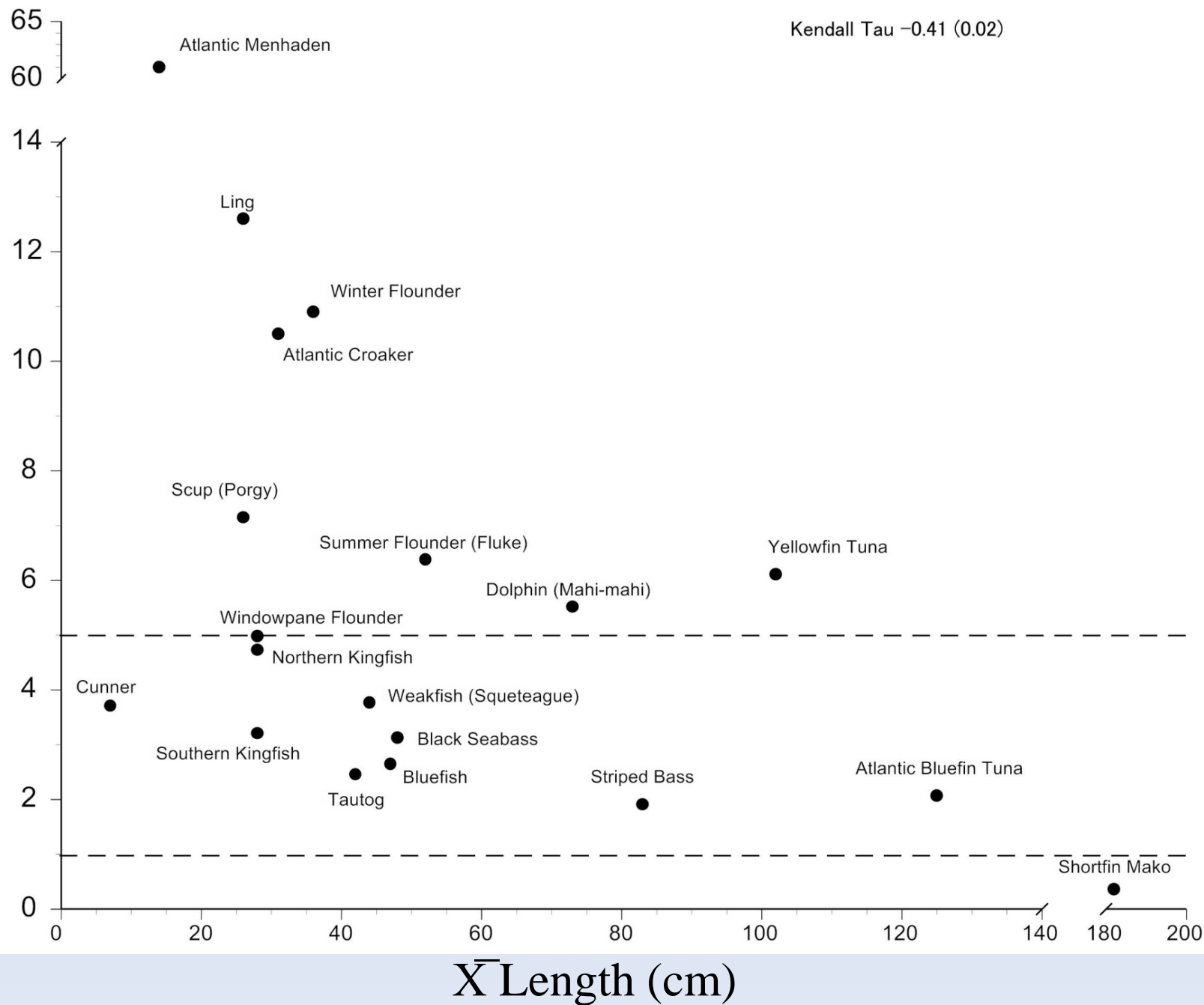
Se:Hg Molar Ratio



$\bar{X}$  Mercury (ppm)

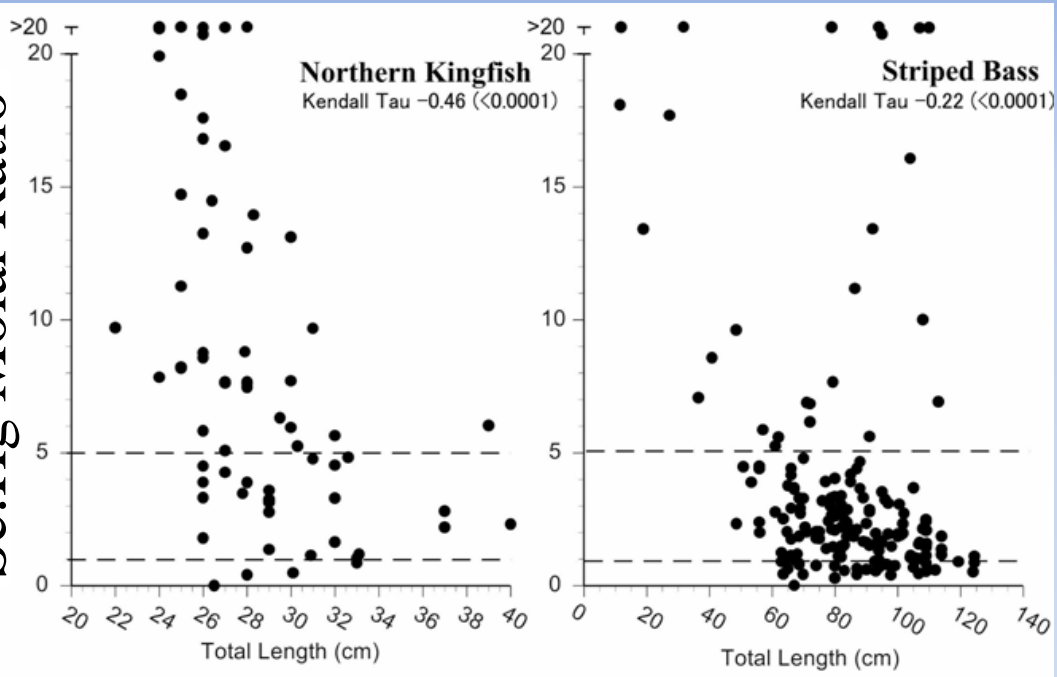
Se:Hg Molar Ratio

Kendall Tau -0.41 (0.02)

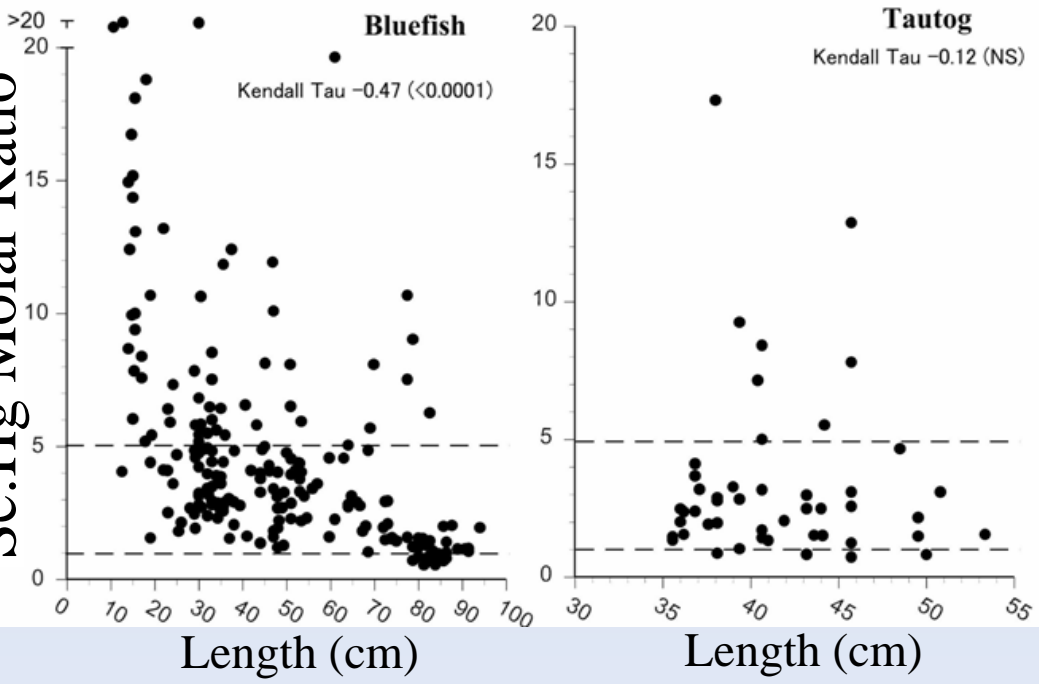


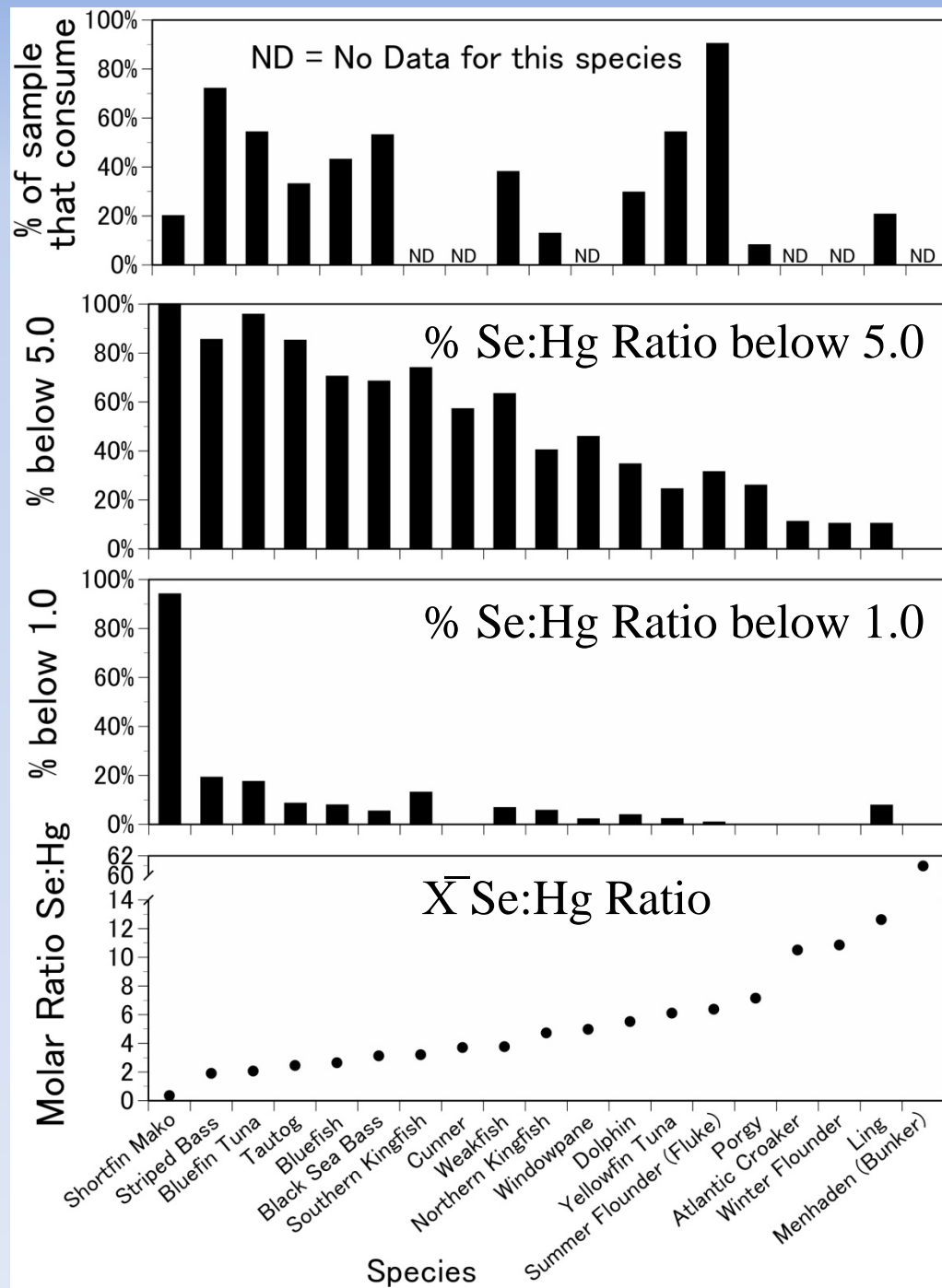


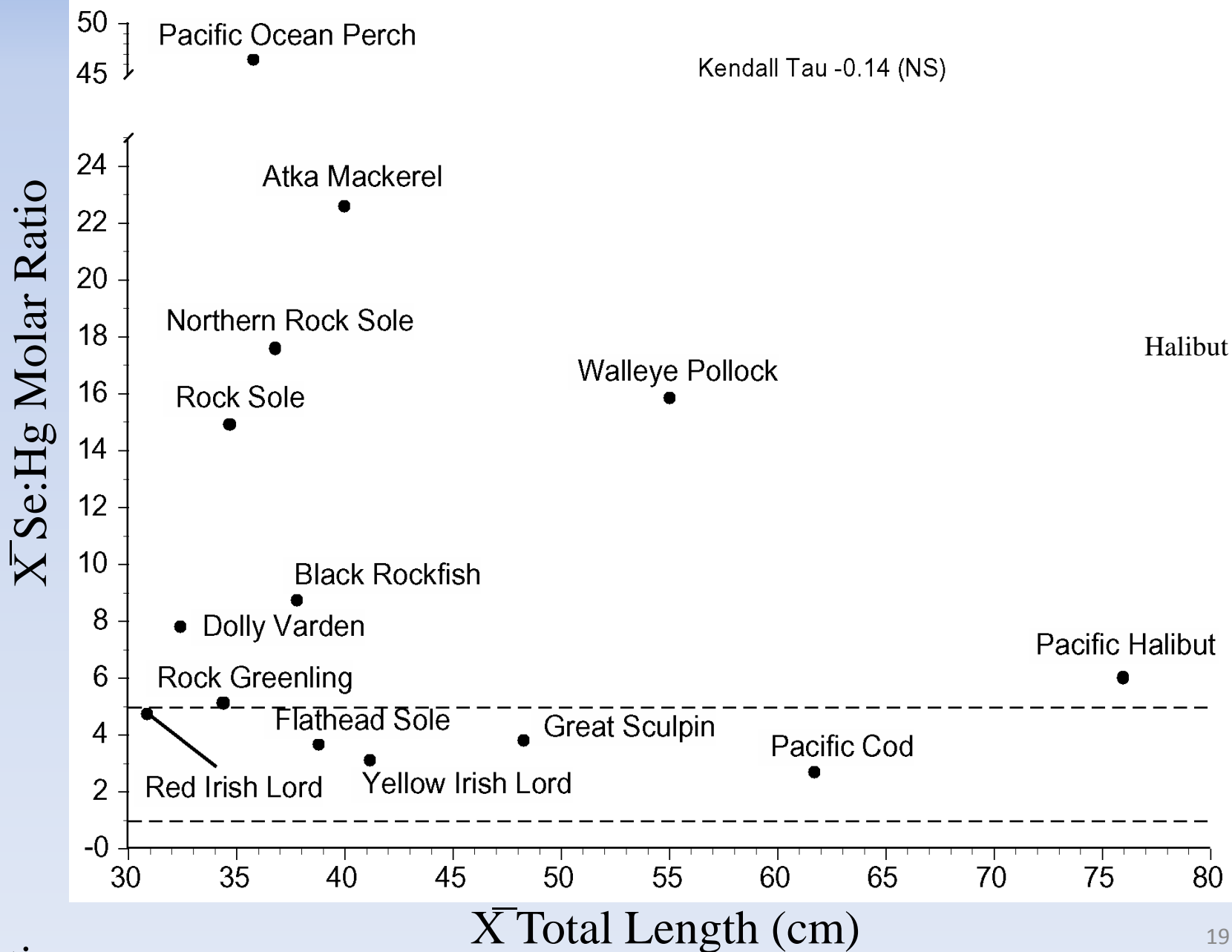
Se:Hg Molar Ratio



Se:Hg Molar Ratio



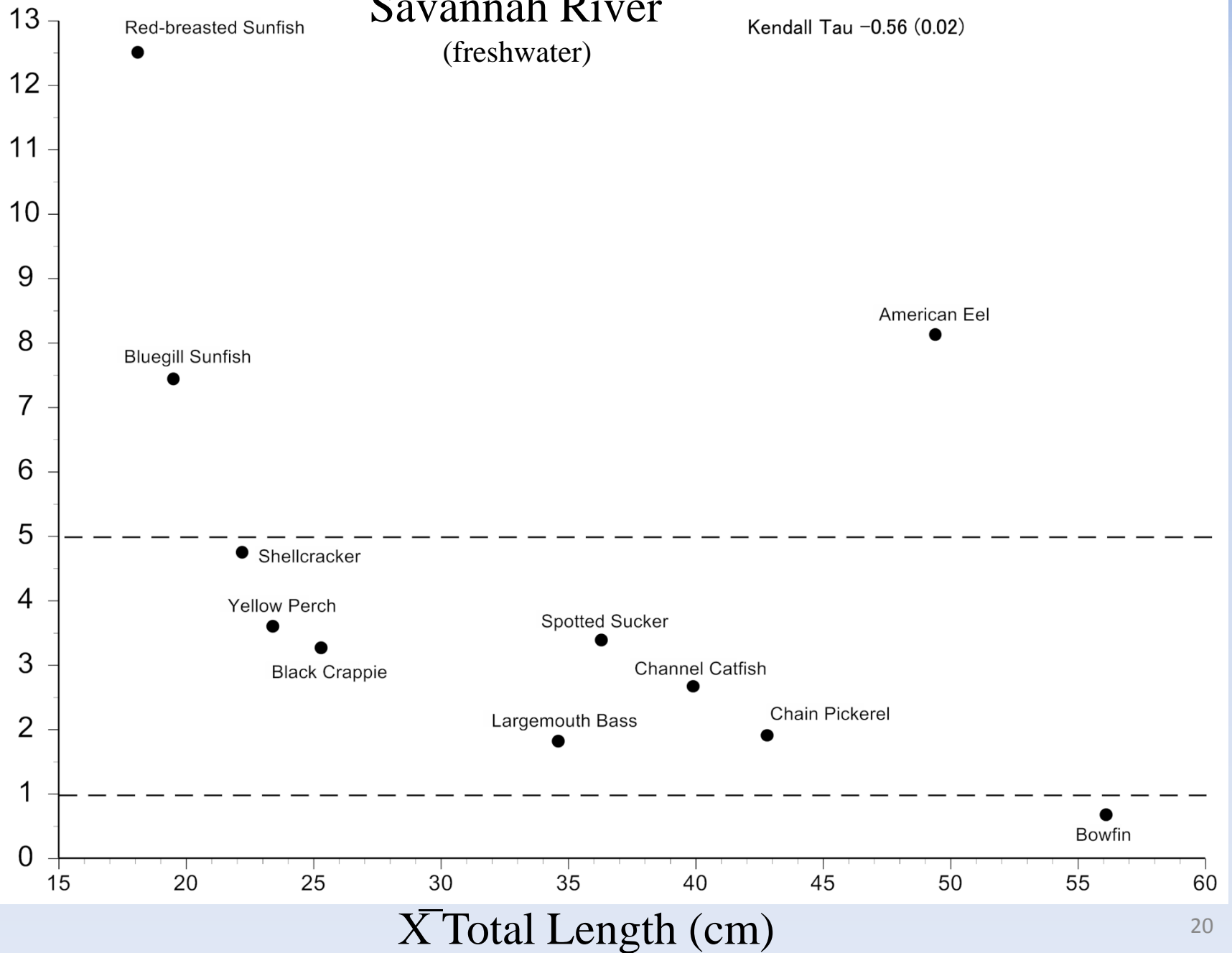




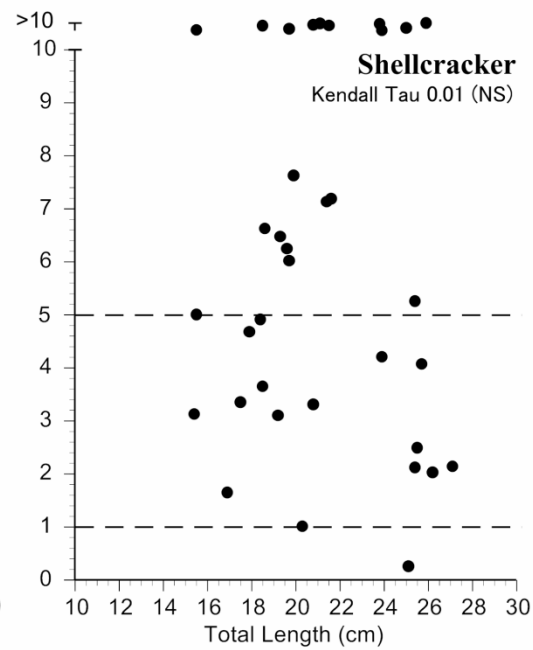
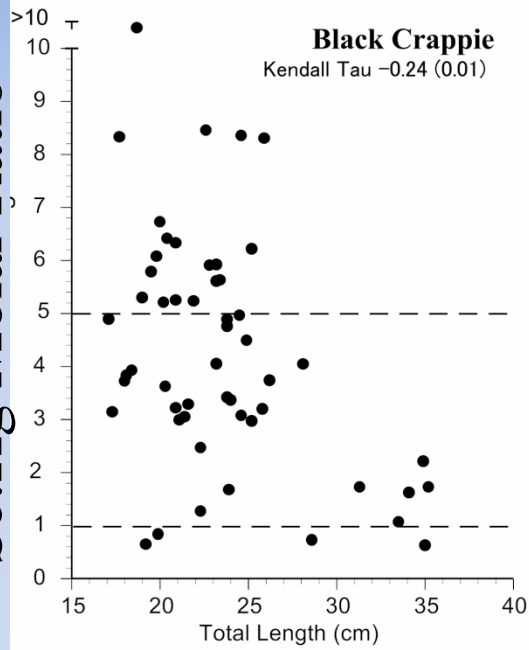
# Savannah River (freshwater)

Kendall Tau  $-0.56$  ( $0.02$ )

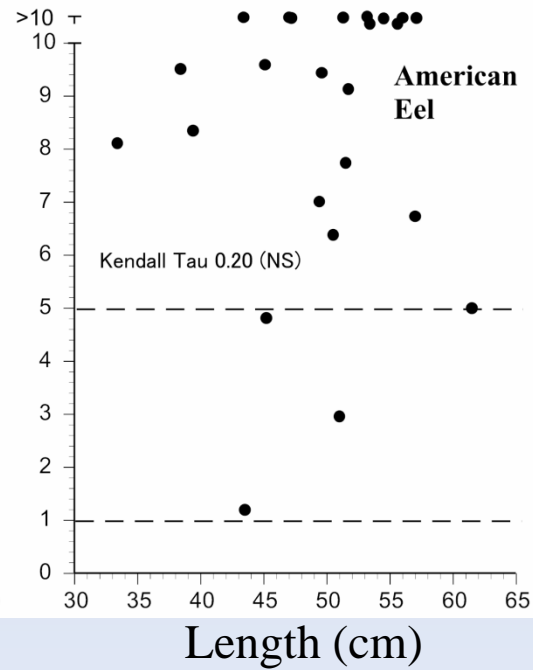
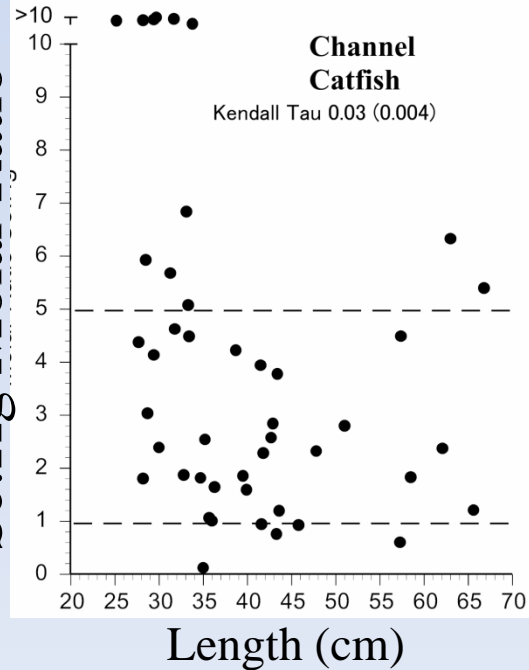
$\bar{X}$  Se:Hg Molar Ratio



Se:Hg Molar Ratio

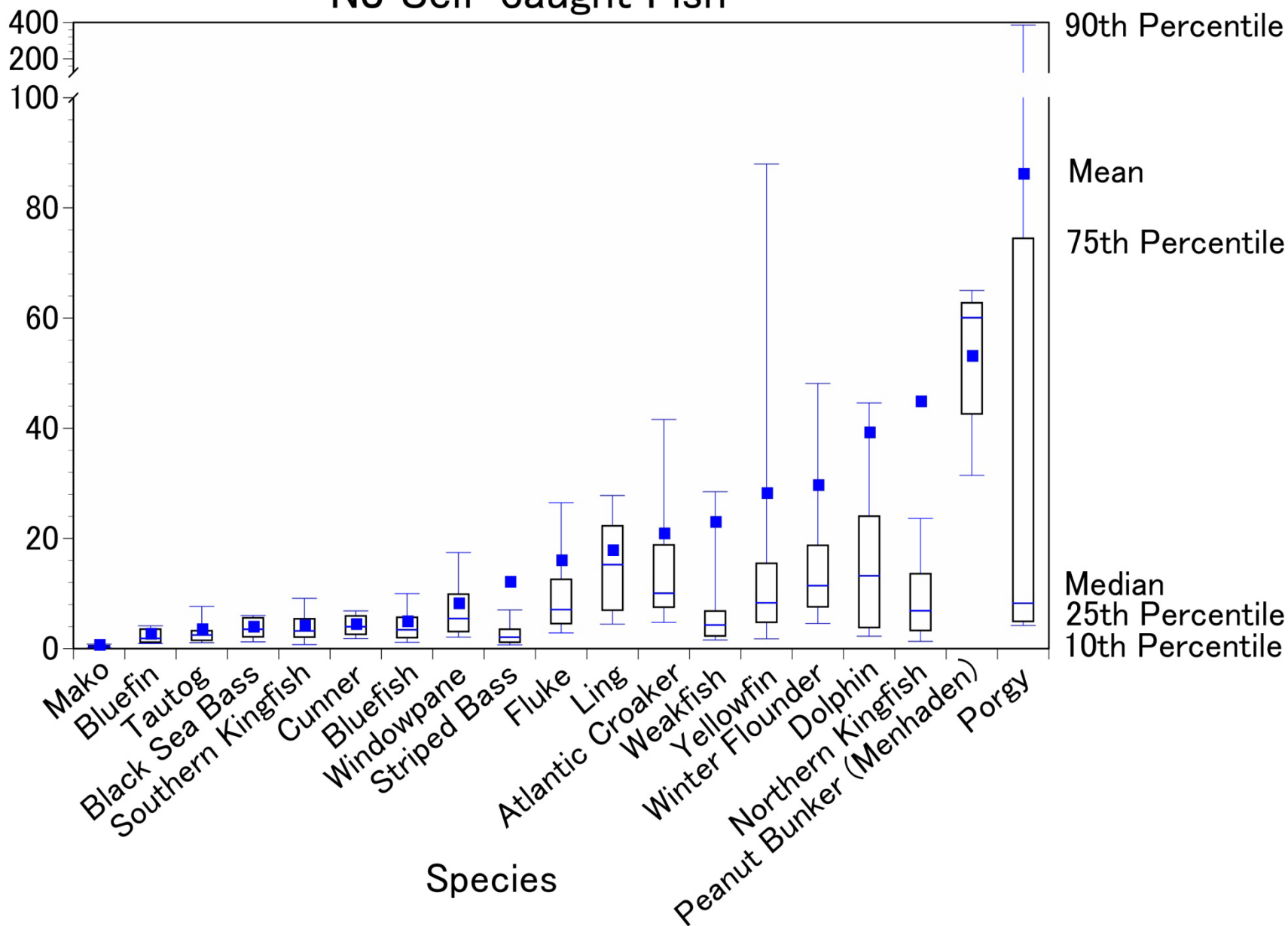


Se:Hg Molar Ratio

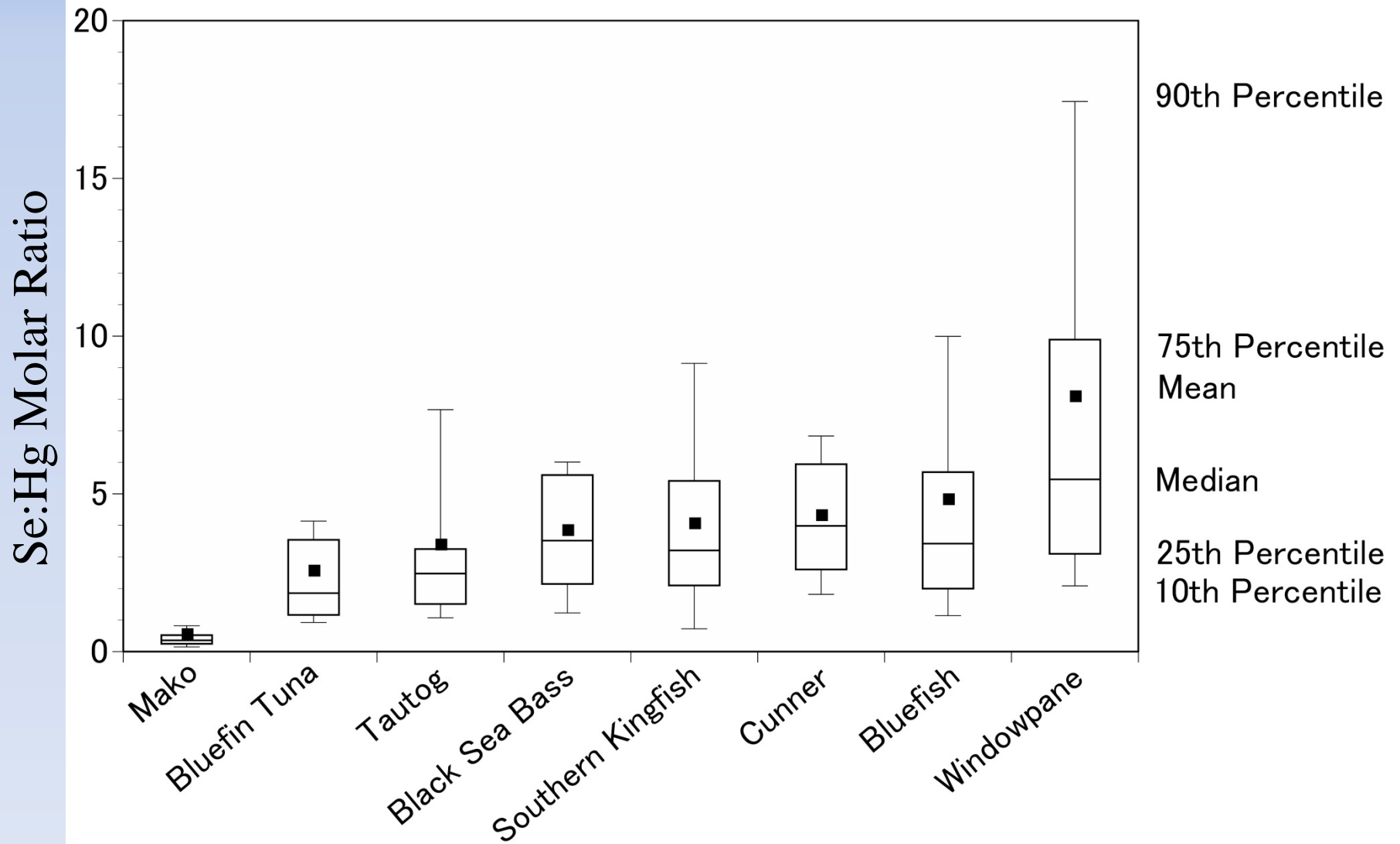


# NJ Self-caught Fish

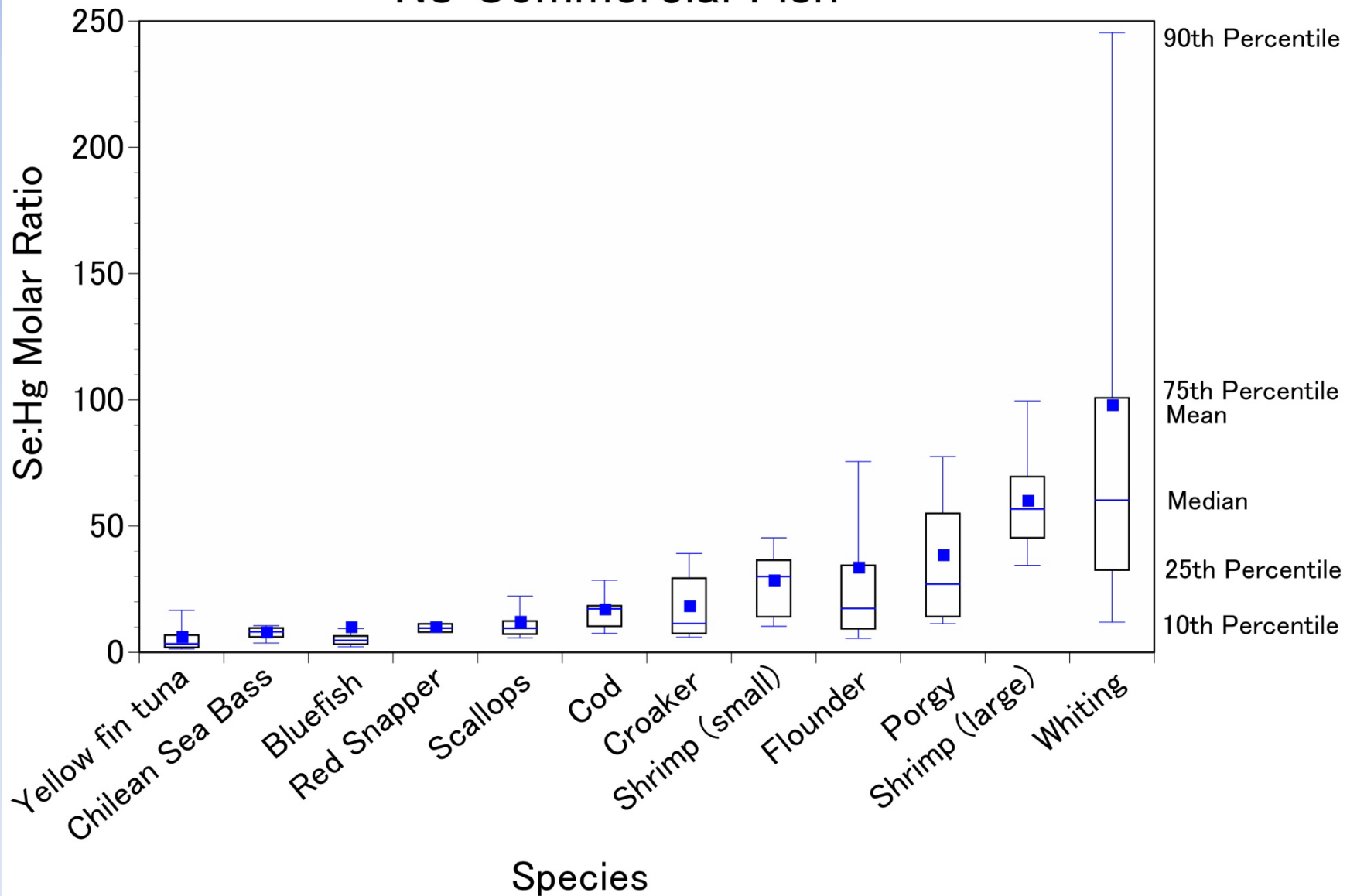
Se:Hg Molar Ratio



# NJ Self-caught Fish

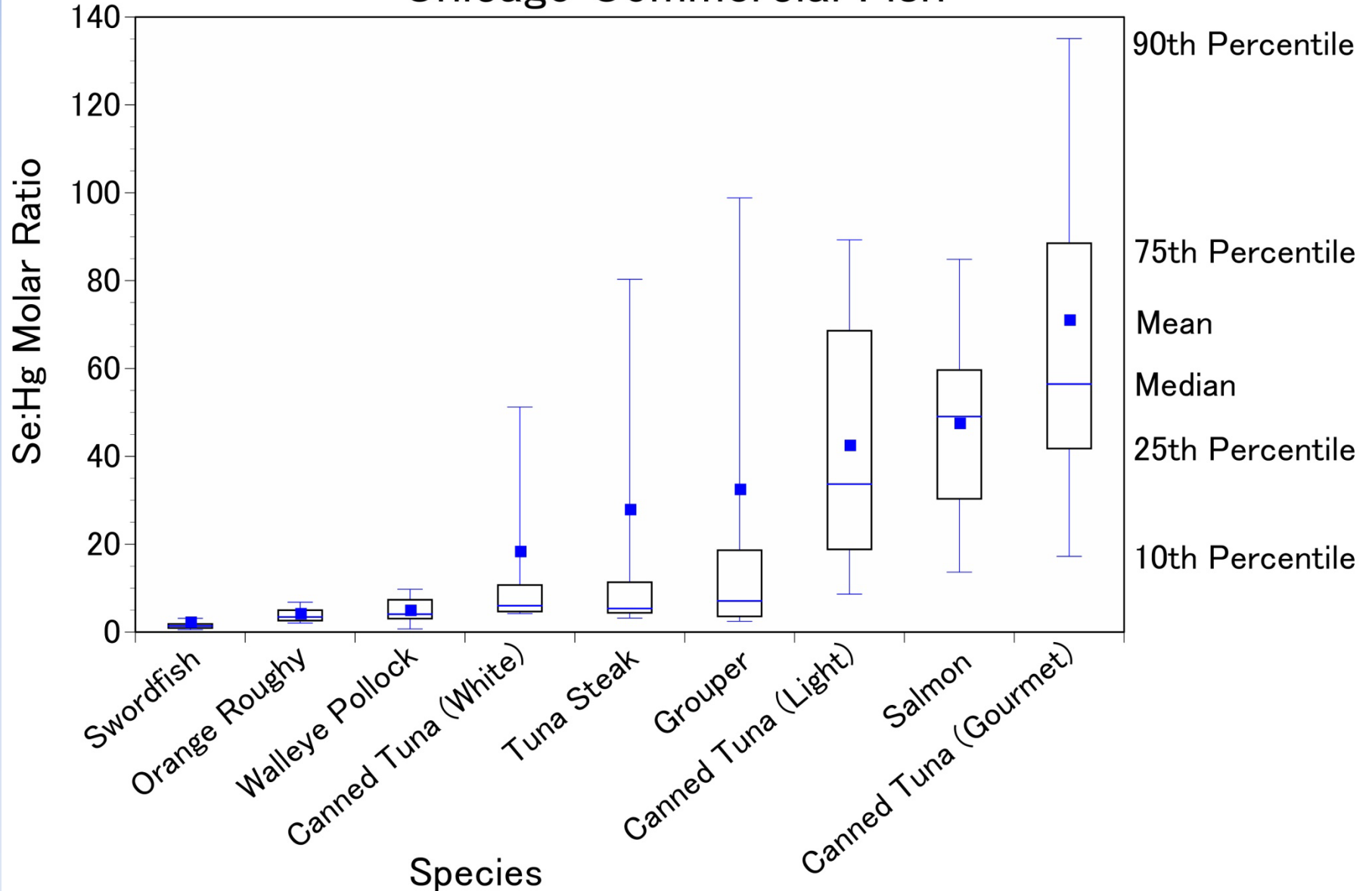


# NJ Commercial Fish

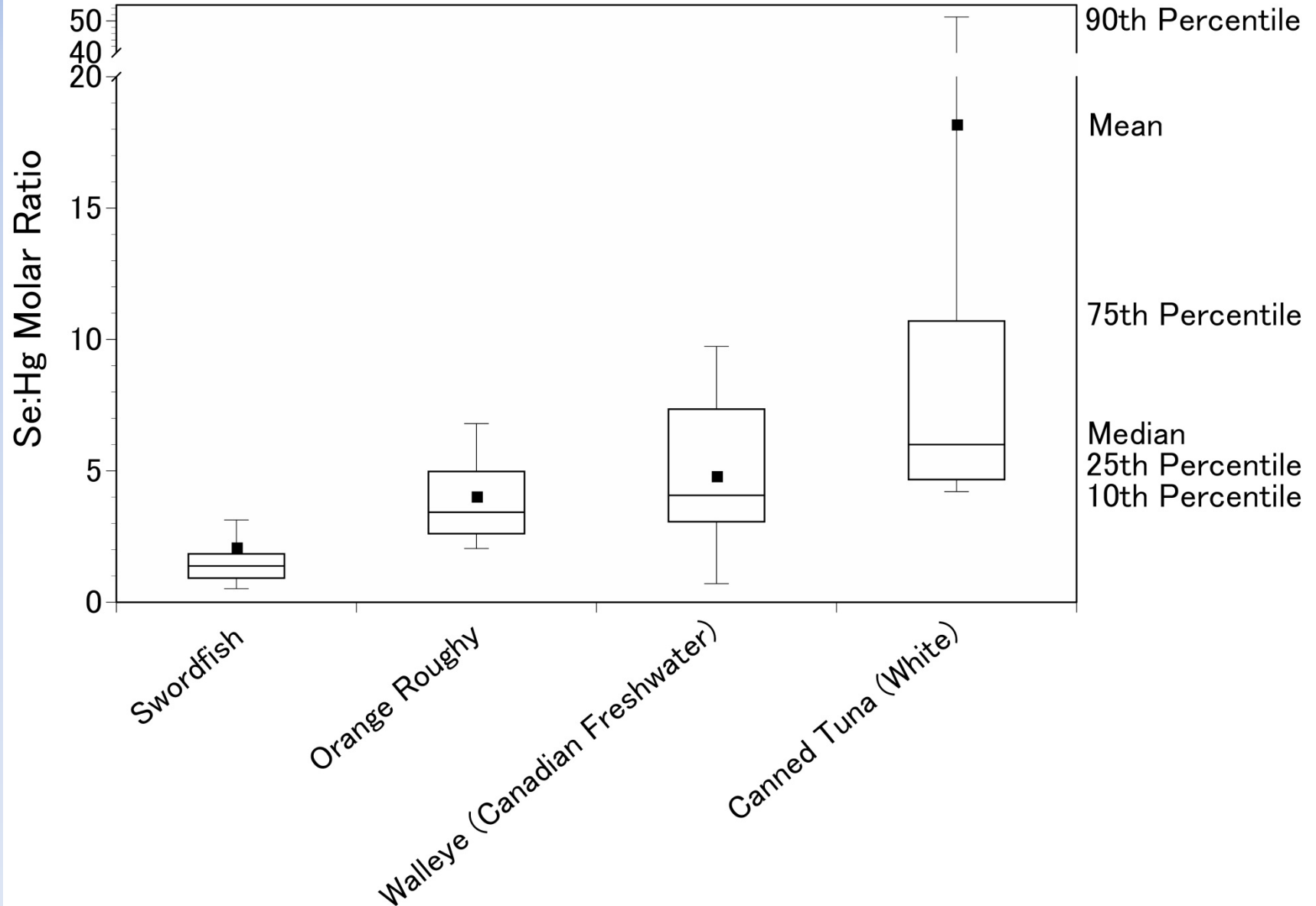




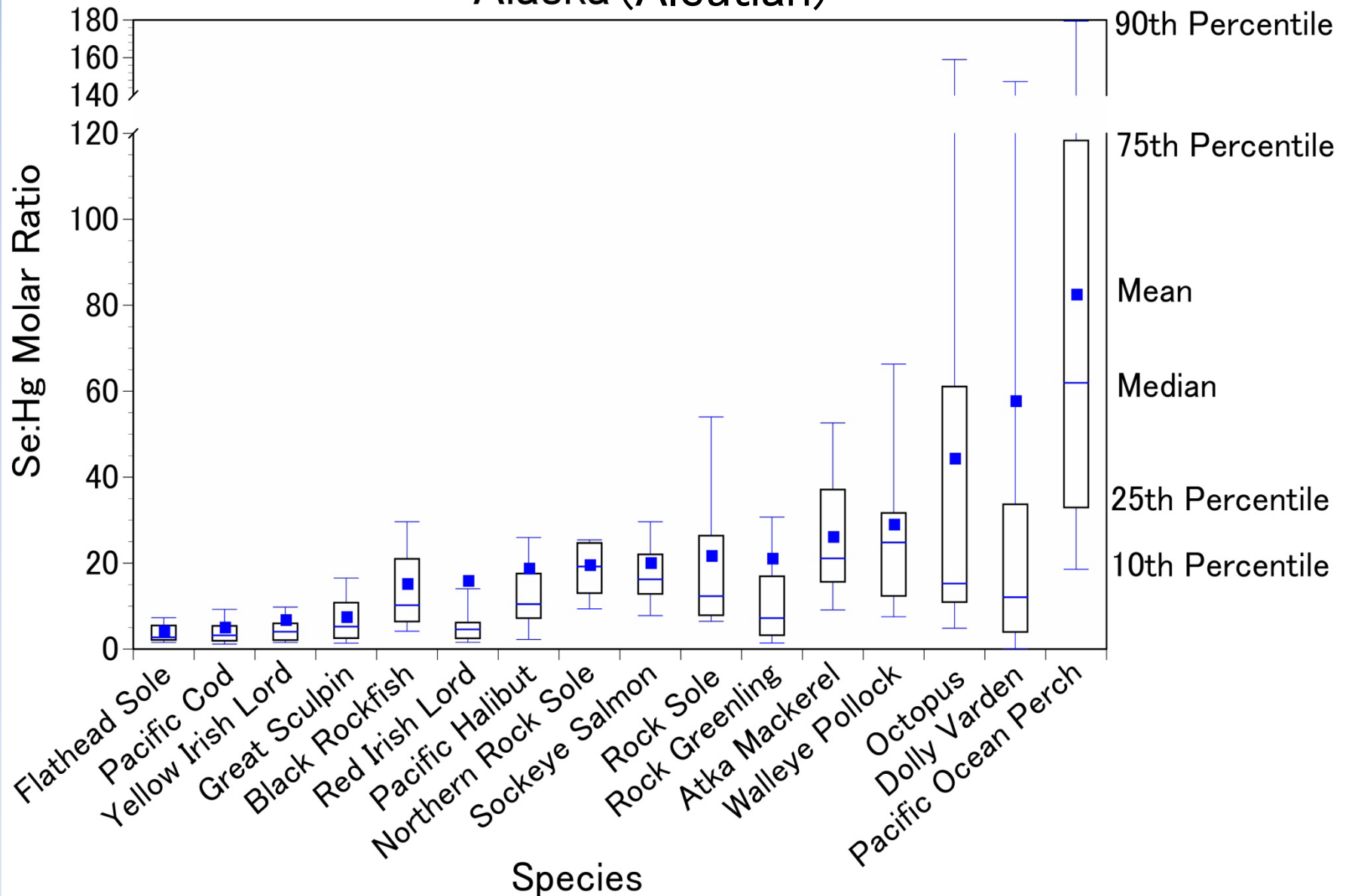
# Chicago Commercial Fish



# Chicago Commercial Fish

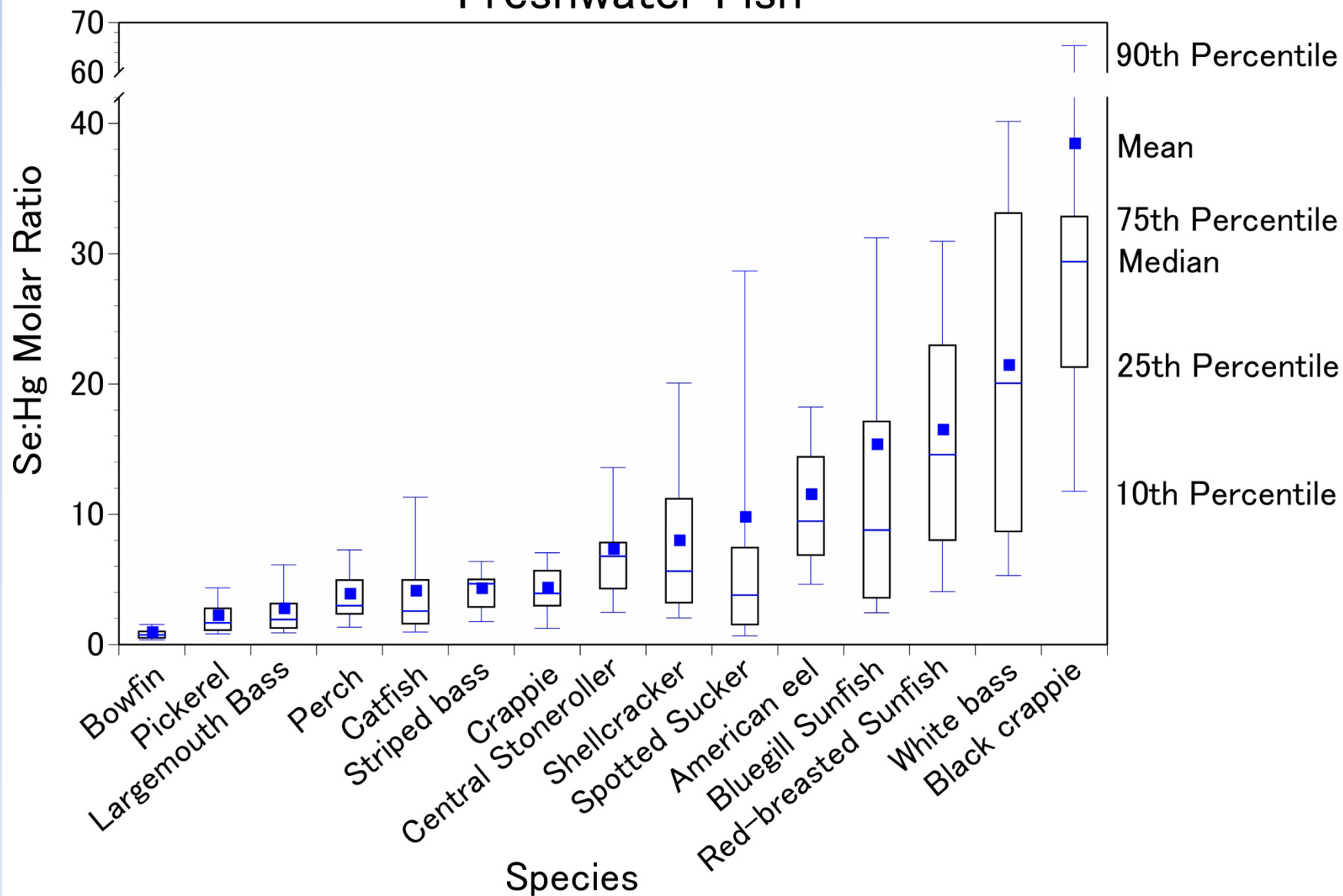


# Alaska (Aleutian)

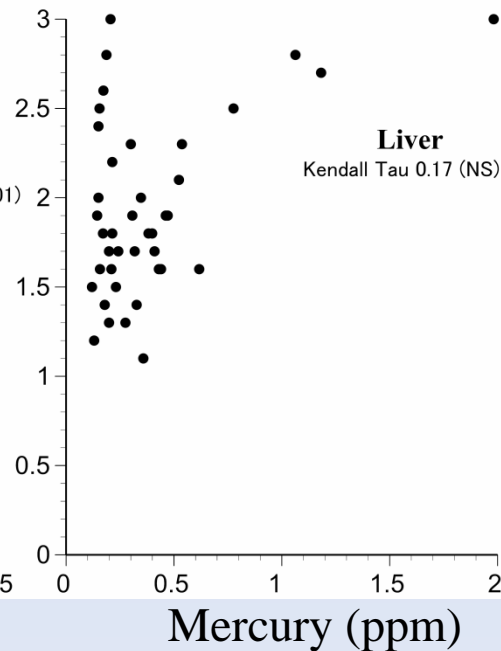
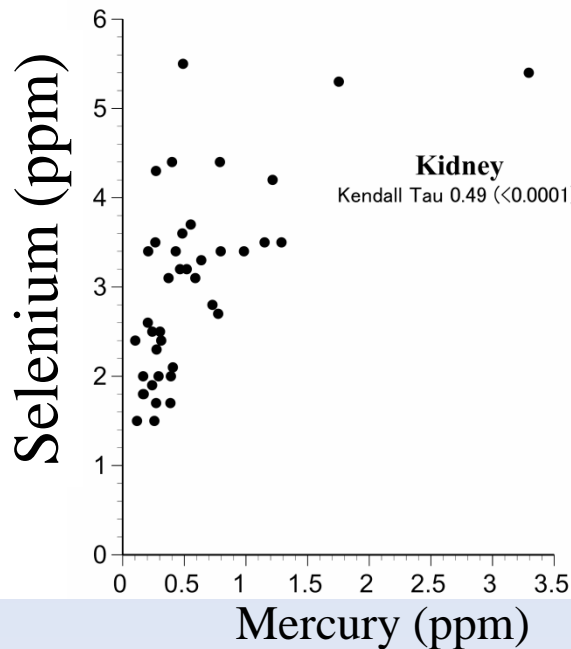
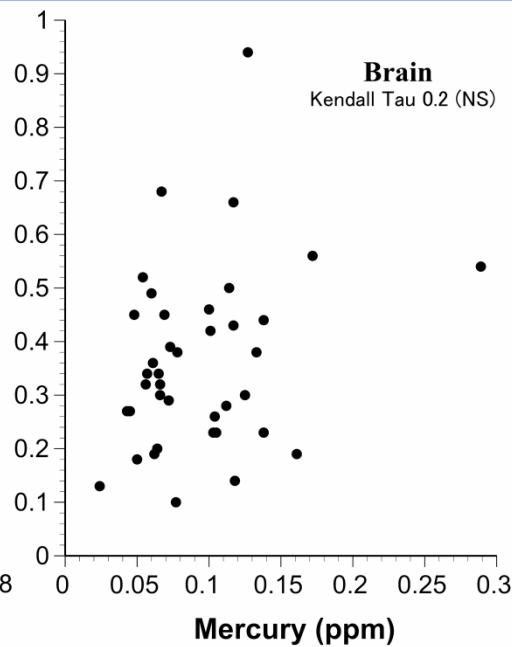
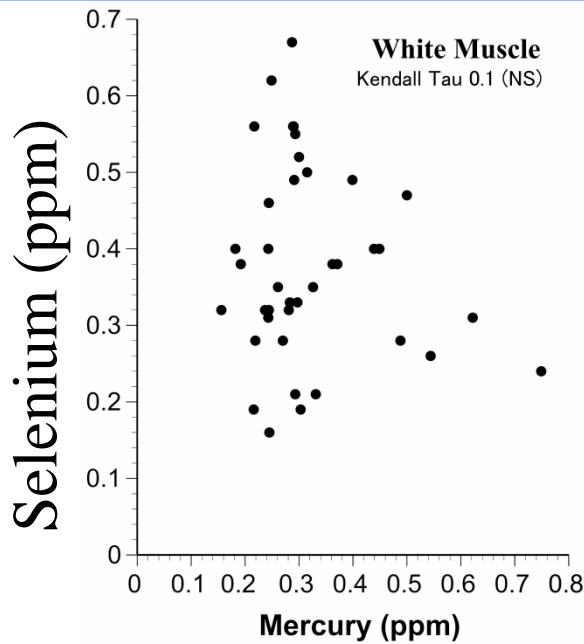


# SAVANNAH RIVER, SC

## Freshwater Fish



# Bluefish



# Implications for Risk Management and Fish Advisories

- There is variation within and among Fish in:

Hg levels

Se levels

Se/Hg ratio

- There is seasonal and yearly variations in all three
- High variability      Low predictability
- Se/Hg molar ratio not yet usable for Fish Advisories



# ACKNOWLEDGMENTS